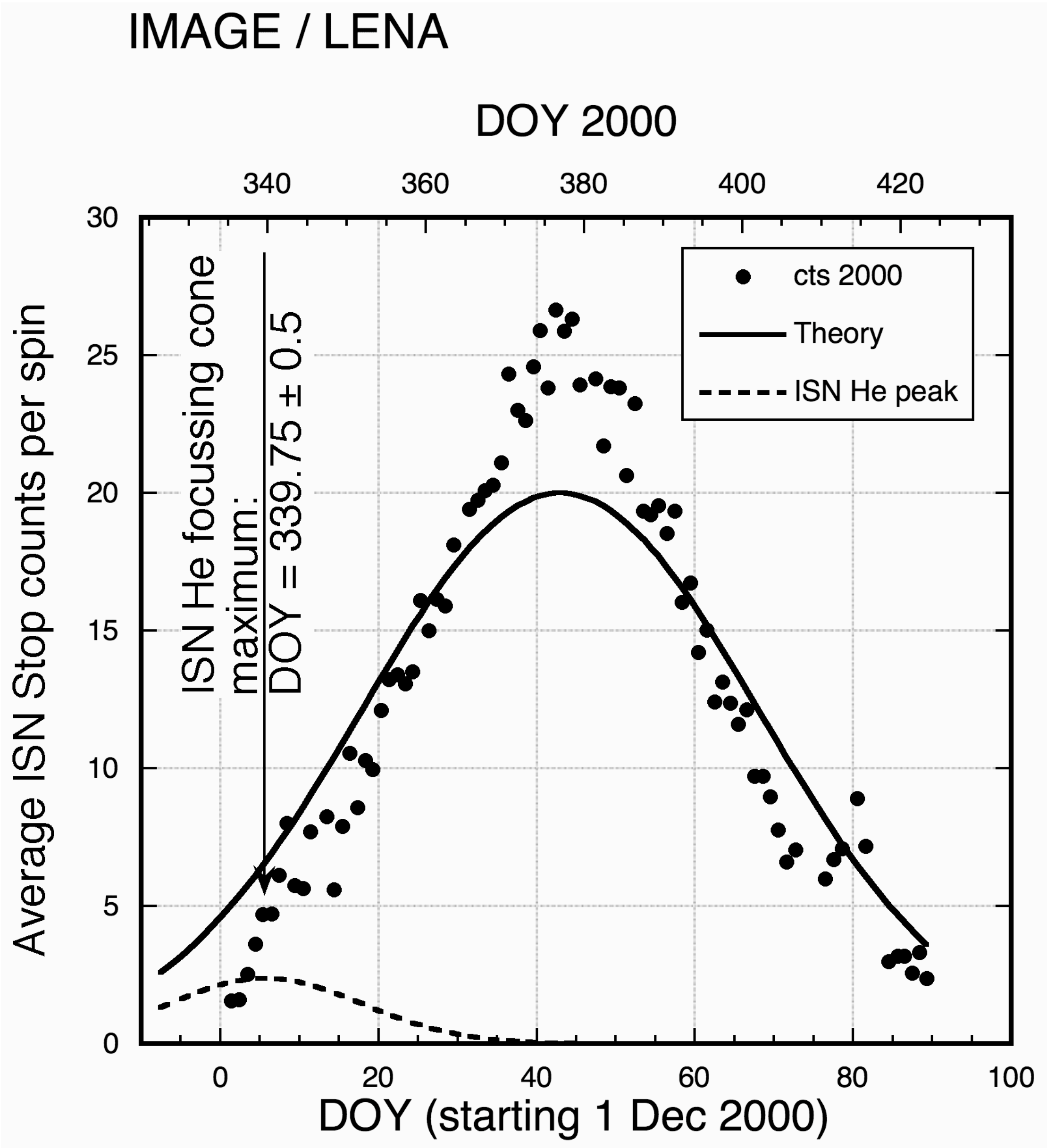
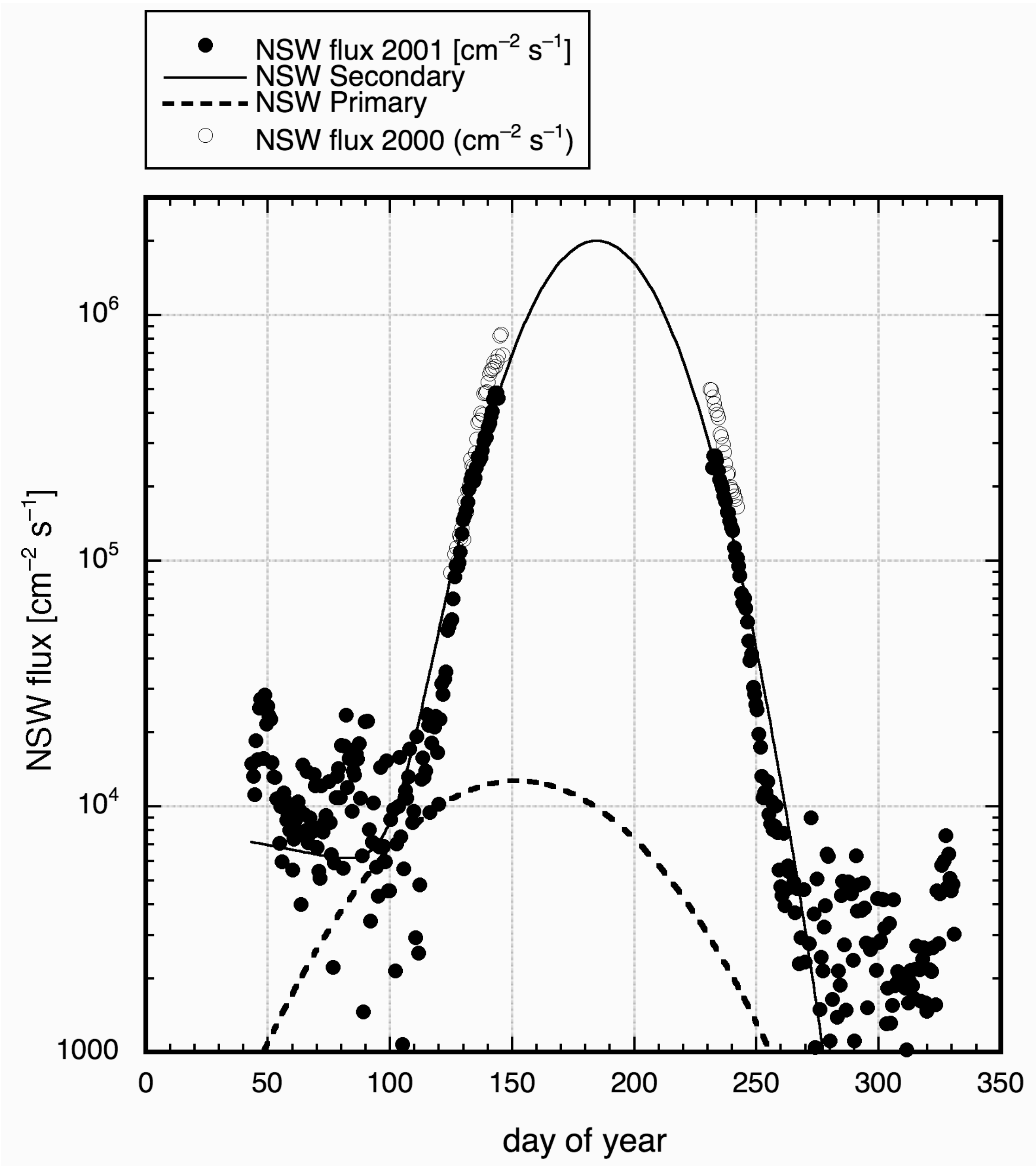


- Peak is offset from expected location by about 30 days
- Flux higher than the expected He ISN signal
- Detection via sputtering → higher energy primary

Different signal source than ISN.
Signal most likely is neutral H, at bout 1 keV energy



$$n_{ISN}(r) = n_0 \exp\left(- \frac{\beta\, r_1^2}{v_{ISN}\, r} \frac{\phi}{\sin \phi} \right)$$

β ……. ionisation rate at 1 AU
n_0 …... density of the interstellar gas at the termination shock
v_{ISN} … is the speed of the inflowing ISN hydrogen
ϕ ……. is the position of the observer relative to the upstream direction of the ISN gas
$r_1 = 1\ AU$

For simplification we assume that the gravitational force balances the photon pressure ($\mu = 1$).

The neutral solar wind resulting from the inflow of ISN and the subsequent charge exchange with solar wind protons is given by

$$\Phi_{NSW}^{ISN}(r) = \Phi_{SW}\, \sigma\, n_0 \frac{v_{ISN}}{\beta} \frac{\sin\phi}{\phi} \exp\left(- \frac{\beta\, r_1^2}{v_{ISN}\, r} \frac{\phi}{\sin\phi} \right)$$

$\Phi_{SW} = v_{SW}\, n_{SW} \approx 4 \cdot 10^8\, cm^{-2} s^{-1}$ is the solar wind flux

$\sigma = 2 \cdot 10^{-15}\, cm$ is the charge exchange cross section

Using $v_{ISN} = 22\, km/s$ and $n_0 = 0.17\, cm^{-3}$ we get for the expected NSW flux in the upwind direction ($\phi = 0$):

$$\Phi_{NSW}^{ISN} = 1.27 \cdot 10^4\, cm^{-2} s^{-1}$$

The contribution of this process to the NSW is shown in the figure as dashed line.

We assume that the large enhancement seen in the figure is also NSW but arising from charge exchange with a secondary flux of neutral hydrogen, since these NAs arrive from the direction of the Sun as well. Thus we also can write for this flux

$$\Phi_{NSW}^{SF}(r) = \Phi_{SW}\,\sigma\,\tilde{n}_0\,\frac{v_{SF}}{\beta}\,\frac{\sin\phi}{\phi}\exp\left(-\frac{\beta r_1^2}{v_{SF}\,r}\,\frac{\phi}{\sin\phi}\right)$$

where, $\tilde{n}_0$, v_{SF}, $\Phi_{NSW}^{SF}(r)$ have the same meaning as before but for the secondary flux of neutral atoms, with from the fit given in the figure

$$\Phi_{NSW}^{SF}(1\,AU) = 2\cdot 10^6\,cm^{-2}s^{-1}$$

Assuming this secondary flux is dominantly hydrogen atoms (the most likely candidate) and that their velocity is $v_{SF} = 440\,km/s$ (i.e., their energy is about 1 keV) we derive for the density of the secondary flow by inverting $\Phi_{NSW}^{SF}(r)$:

$$\tilde{n}_0 = \frac{\phi}{\sin\phi}\,\beta\,\frac{\Phi_{NSW}^{SF}}{v_{SF}\Phi_{SW}\sigma}\exp\left(\frac{r_1^2}{r}\,\frac{\beta}{v_{SF}}\,\frac{\phi}{\sin\phi}\right)$$

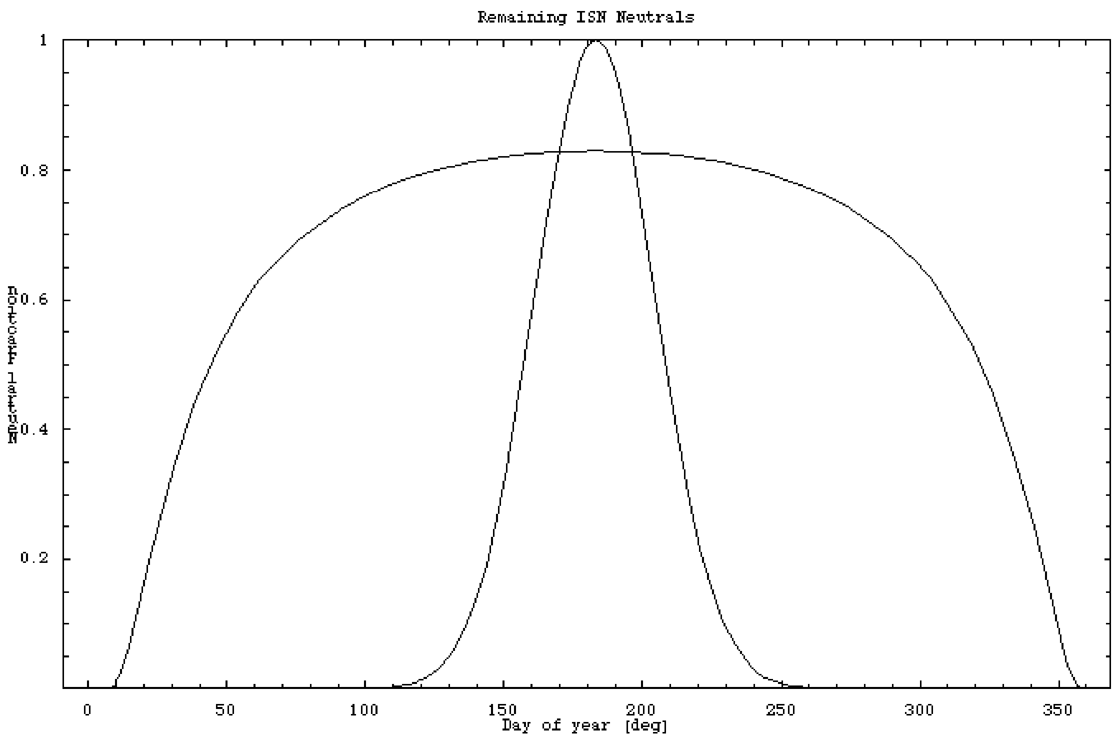
Being at Earth orbit ($r = 1\,AU$) this gives for the density of the secondary flow

$$\tilde{n}_0 = 0.038\,cm^{-3}$$

and compared to the ISN gas we obtain

$$\tilde{n}_0 / n_0 = 0.22$$

Since the velocity of the secondary flow is rather high there is hardly an effect of the ionisation in the upwind region and the shape of the measured distribution is a result of the source distribution. Evaluating ionisation for the parameters of the secondary flow we find that in the upwind direction of the secondary flow the neutral fraction arriving at 1 AU is about 83% and on the sides 55° away of the upwind direction the neutral fraction is still 80%. Thus the shape of the secondary flux most likely represents the spatial distribution in longitude of the source of these particles.



$$n_{SF}(r) = \tilde{n}_0 \exp\left(- \frac{\beta r_1^2}{v_{SF}\, r} \frac{\phi}{\sin\phi} \right)$$

with $v_{SF} = 440\ km/s$

The signal of the secondary flow is well characterized by a Gaussian distribution with

$$\sigma = 23.6^\circ$$

and a peak flux

$$\Phi_{NSW}^{SF}(1\,AU) = 2 \cdot 10^6 cm^{-2} s^{-1}.$$

With this description we can investigate what happens to this flow when it passes the Sun and propagates into the downwind region. To obtain the flux in the downwind region we have to integrate the ionisation probability along the particle trajectory, multiplied by the distribution of the source in longitude and the temperature of the source:

$$\begin{aligned}\Phi_{ISN}(\phi_0) = \quad & \int \exp\left(-\frac{\beta r_1^2}{v_{SF}\, r}\frac{\phi}{\sin\phi}\right) \times \\ & \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2}\frac{\left(\phi-\phi_0\right)^2}{\sigma^2}\right) \times \\ & \frac{1}{\Delta\phi_T\sqrt{2\pi}} \exp\left(-\frac{1}{2}\frac{\left(\phi-\phi_0\right)^2}{\Delta\phi_T^{\;2}}\right) d\phi\end{aligned}$$

where the last term refers to the temperature of the source, which is given by

$$\Delta\phi_T = \arctan\left(\frac{1}{v_{SF}}\sqrt{\frac{2\,k_B\,T}{m}}\right)$$

The evaluation gives a peak flux at the downwind side of the secondary component of

$$630 \pm 200\, cm^{-2} s^{-1}.$$

By applying LENA/IMAGE efficiencies we get a peak signal of

$$20 \pm 9\; cts\, /\, spin\,,$$

which is in good agreement with the observed peak signal of

$$27\; cts\, /\, spin\,.$$

To get agreement with the observed downwind data the temperature of the source was used as fit parameter and the best agreement between data and calculation was found for a value of

$$T = \left(2.5 \pm 0.5\right) \cdot 10^{4}\; K\,.$$

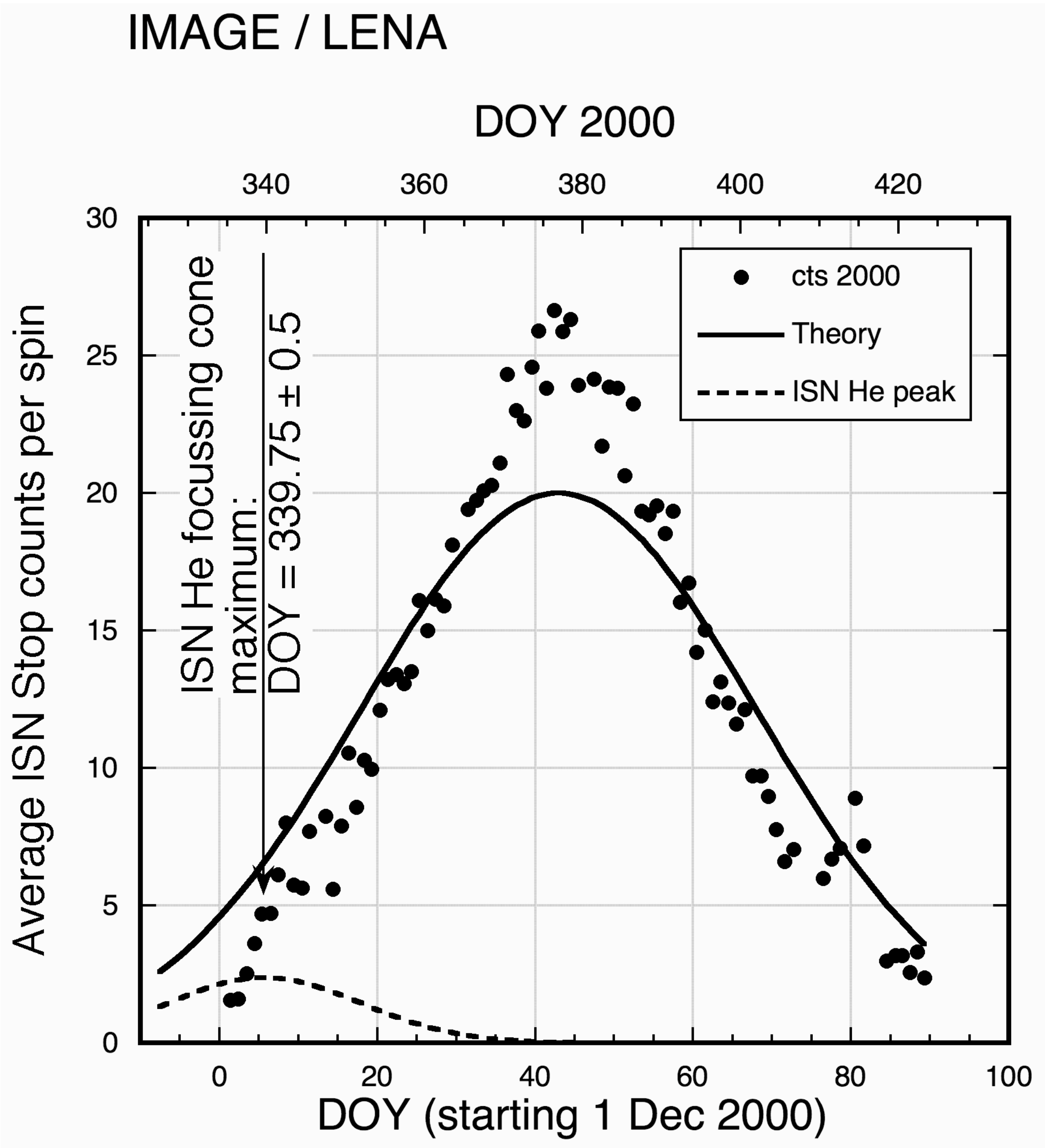
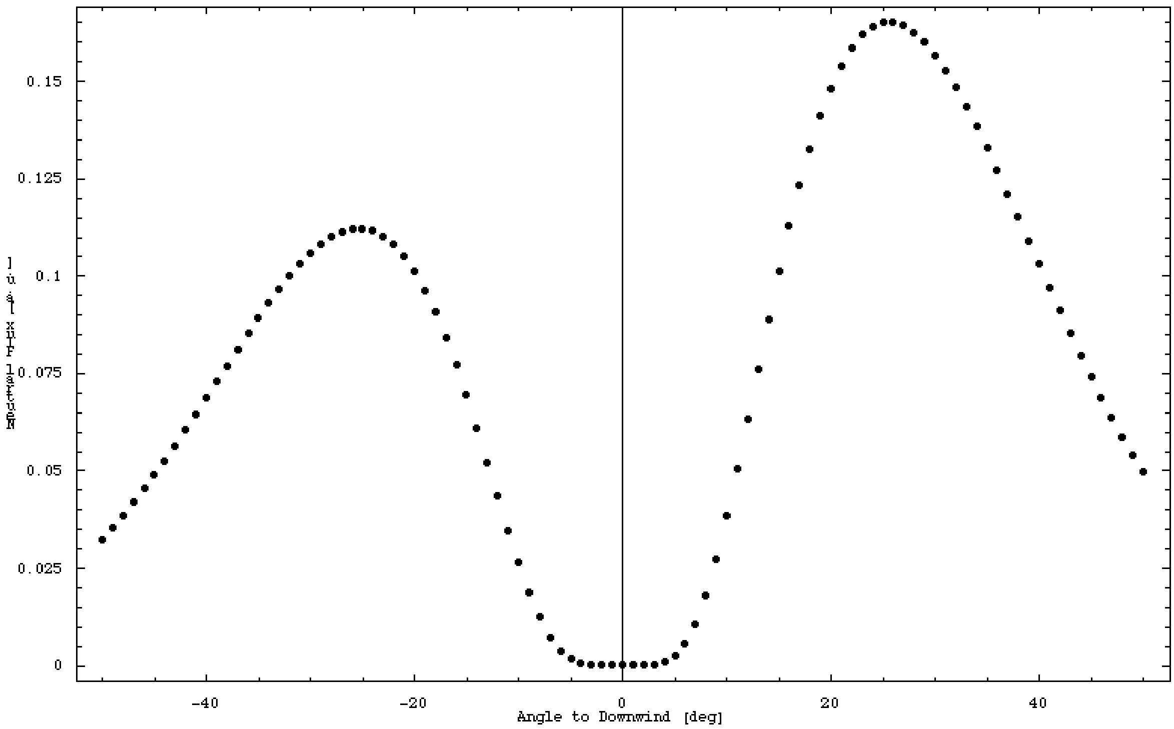


IMAGE / LENA
DOY 2000
340
360
380
400
420
Average ISN Stop counts per spin
0
5
10
15
20
25
30
ISN He focussing cone maximum: DOY = 339.75 ± 0.5
cts 2000
Theory
ISN He peak
0
20
40
60
80
100
DOY (starting 1 Dec 2000)

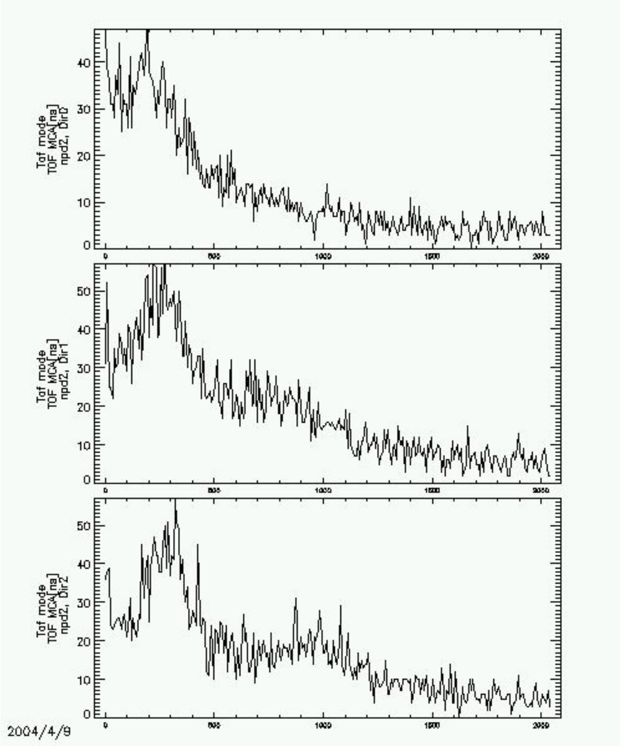
Note that the observed downwind distribution of the secondary component cannot be explained by a parallel flow with a high temperature of $T = 2 \cdot 10^6\,K$, which corresponds to the observed width in longitude. For that case, the resulting distribution on the downwind side is too different from the observations. .

$$T = \frac{m}{2\,k_B}\left(v_{SF}\ \tan(\Delta\phi_L)\right)^2$$



ASPERA-3 / Mars Express

NPD TOF Spectra



- Mass: **hydrogen** (very short TOFs)
- Beam energy: **810 eV**